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# NEW RIG TO TEST JOURNAL OIL LUBRICATED WAVE BEARINGS

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## ABSTRACT

A new rig to test journal fluid film bearings was designed, manufacture and installed at NASA Glenn Research Center in Cleveland, Ohio, USA. This rig can apply total radial loads to 133,000 N (30,000 lbs) and can rotate the shaft to speeds to 13,000 RPM. The test bearing has a diameter of 68 mm and is 38 mm long. Two such bearings are used to support the total load. The shaft is also supported by two fluid film bearings. The rig is well instrumented for measuring oil flow, oil inlet and outlet temperatures, bearing sleeve temperatures along its circumference and the oil temperatures in oil supply pockets. The shaft position is monitored by proximity probes. Vibration levels at four locations are also displayed and recorded. Preliminary tests of wave bearings at 8,000 RPM and loads to 20,000 N (4,500 lbs) show a good correlation between the test and prediction data.

## INTRODUCTION

Oil lubricated wave bearings have been tested at NASA GRC since 1997 when the first rig to test such bearings was in operating conditions. That rig can apply radial loads to 9,000 N and can run the shaft at rotating speeds to 60,000 RPM. First test results where published in 2000 [1]. Then the rig was used for stability study of the wave bearings as presented, for example in reference [2]. This rig was also used to test wave bearings lubricated with liquids at temperature to $350^0$C [3]. Recently, tests for PVD coatings applied to both the rotor and the sleeve surfaces at start-stop and oil-off condition are in progress and results were reported in, for example, in reference [4].

New investigation on the application of the wave bearings in aero-transmission have required tests of the wave bearings under extremely loaded condition (specific loads to 3,500 MPa). Therefore, a new rig was designed, manufactured and installed at NASA GRC in the oil wave bearing test facility. Preliminary test data will be presented below.

## RIG DESCRIPTION

The new rig was ready to operate in August 2006. It shares the oil system some of the instrumentations, display units, turbine controller, and data acquisition with the original rig build in 1997. A general view of the rig facility can be seen in Figure 1.

This rig can apply total radial loads to 133,000 N (30,000 lbs) and can rotate the shaft to 13,000 RPM. The test bearing has a diameter of 68 mm and is 38 mm long. Two such bearings are used to support the total load. The shaft is also supported by two fluid film bearings. The rig is well instrumented for measuring oil flow, oil inlet and outlet temperatures, bearing sleeve temperatures along its circumference and the oil temperatures in oil supply pockets. The shaft position is monitored by proximity probes. Vibration levels at four locations are also displayed and recorded. A 3D cross section of the rig can be seen in Figure 2.

The test and the shaft support bearings are wave bearings. The test bearings have 37 microns radial clearance and 0.184 wave amplitude to radial clearance ratio. The axial position of the shaft is kept by two thrust wave bearings. The shaft is rotated by a double disk air turbine that can deliver 28 kw at 15,000 RPM.

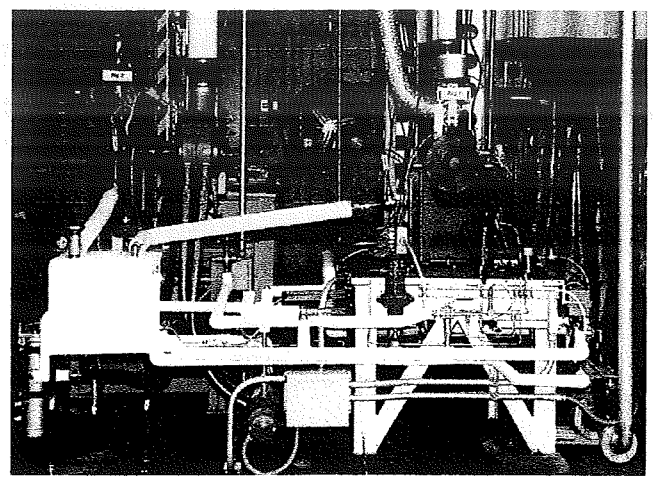

**Figure 1, General View of the Fluid Film Bearing Test Facility at NASA Glenn Research Center in Cleveland, Ohio.**

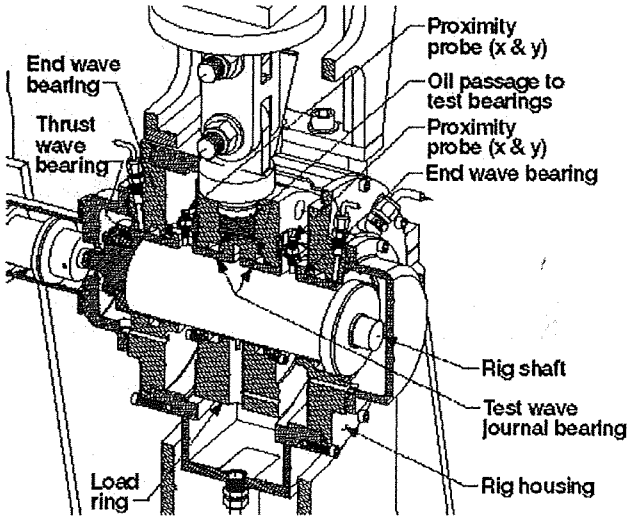


**Figure 2, 3D Cross Section of the New Rig**

Thermocouples are installed to record the temperature in the middle of the metal sleeve around the bearing and in the oil supply pockets. A view of the load ring from the turbine side can be seen in Figure 3. As may be seen in the figure the thermocouples are labeled in the following manner: thermocouples 3 and 7 – 17 are located in the middle of the sleeve metal; thermocouple 5 is located in the output chamfrain of the sleeve; thermocouples 6-4, 6-5, and 6-6 indicate the temperature of the load ring. A, B, and C are thermocouples installed in the oil supply pockets. The support of the proximity probes was removed when the photograph was taken but the positions of the probes are labeled as X22 and Y22. A similar arrangement of the thermocouples and proximity probes is on the opposite side of the load ring.

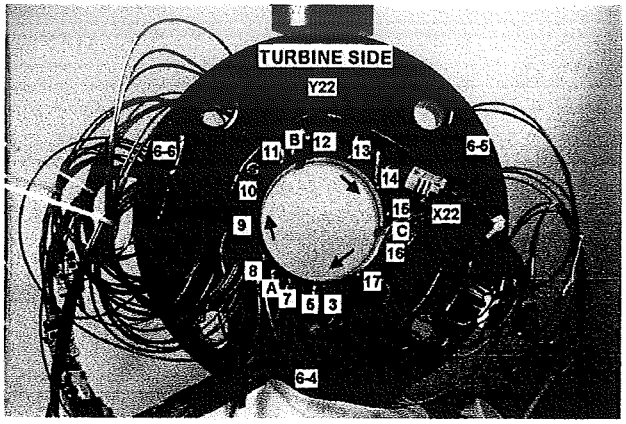


**Figure 3 View of the Load Ring of Rig #2 from the Turbine Side.**

## TEST RESULTS AND COMPARISON TO PREDICTION

Tests were conducted by operating the rig at 8,000 RPM and the total load applied to the test bearings was increase from 0 to 3,500 lbs. Test data were recorded by Escort Data Acquisition System. Based on this data the increase of oil temperature from inlet to outlet through the test bearings, $\Delta t$, was evaluated at each load. $\Delta t$ was also calculated with the oil wave bearing code for both laminar and turbulent with oil viscosity correction regimes. The test and prediction data can be seen in Figure 3.

Measured temperatures in the middle of the metal sleeve and in the supply pockets for a total radial load applied to the test bearing of 13,300 N (3,000 lbs) when the shaft was spinning at 8,000 RPM can be seen in Figure 4

The oil flow rate through the test bearings was also recorded. This flow rate was also calculated for both regimes as mentioned above. Test and prediction data for the oil flow rate can be seen in Figure 5.

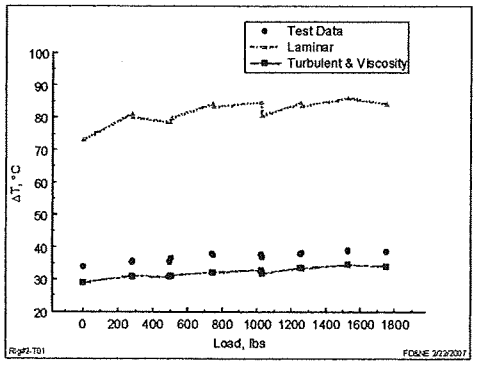


**Figure 3, Oil Temperature Increase $\Delta t$ versus Applied Radial Load per Test Bearing; Test and Prediction Data.**

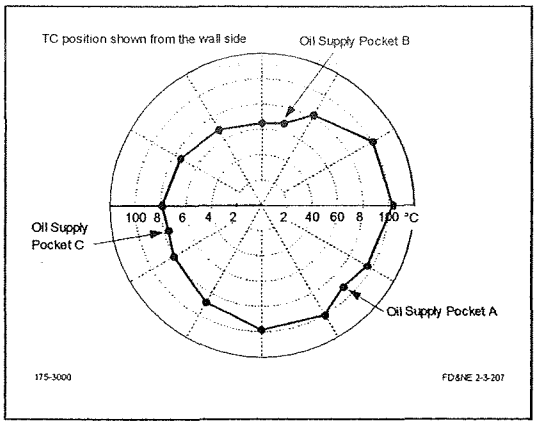


**Figure 4, Measured Temperatures in the Middle of the Metal Sleeve and in the Oil Supply Pockets of the Test Bearing.**

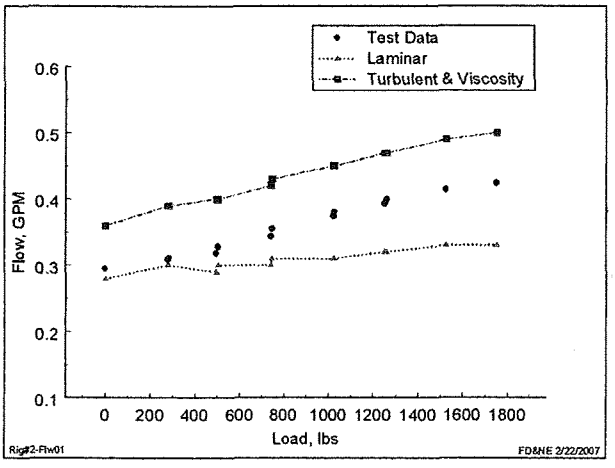


**Figure 5, Oil Flow Rate versus Applied Radial Load per Test Bearing; Test and Prediction Data.**

## CONCLUDING REMARKS

1. The new rig to test fluid film bearing installed at NASA GRC is fully operating and generates complete test data.
2. Comparisons between preliminary test data for oil $\Delta t$ and flow rate with the prediction data generated by the oil wave bearing code shown good correlation validating the prediction.
3. The new rig permits measurement of the temperatures in the metal sleeve and in the oil supply pockets of the test bearing as well.

## ACKNOWLEDGMENTS

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